Analysis of energy consumption in the production of graphene material and its impact on the environmental footprint

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Abstract

This study aimed to compare the energy consumption and its impact on the environmental footprint of eight different technology routes to produce graphene and reduced graphene oxide. This study is part of the Horizon Europe - GIANCE Project (Graphene Alliance for Sustainable Multifunctional Materials to Tackle Environmental Challenges) [1]. One of Fraunhofer's roles in the project is the performance of life cycle assessment (LCA) of the new solutions in comparison with the reference solutions. Therefore, specific database, i.e. life cycle inventory (LCI), are required. However, there is a lack of LCI data of graphene processes, which is one of the main challenges, as the database is the core of an LCA. To overcome this challenge, Fraunhofer ICT has developed life cycle inventories, considering gate-to-gate system boundary, of various processes related to graphene. For graphene production eight processes were chosen based on the GIANCE project's use cases. They are as follows: (i) Chemical reduction of graphite oxide [3]; (ii) Electrochemical exfoliation of graphite [4]; (iii) Ultrasonic Exfoliation [5]; (iv) Hummers method [6]; (v) Marcano's Method [7]; (vi) Chemical oxidation [8]; (vii) Hydrothermal method [9]; and (viii) Annealing method [10]. The Environmental Footprint (EF 3.1) indicators, which were also correlated to the Sustainable Development Goals (SDGs), were used to verify the key environmental hotspots of each process to produce graphene and reduced graphene oxide. The results showed a significant impact on the climate change, toxicity, and human health and on the SDGs 3, 6 and 13. In addition, the study identified potential future development pathways to guarantee the environmental benefits of the next generation of graphene materials.

References

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